Learning cortical representations from multiple whisker inputs

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Rats' whiskers convey tactile information to the somatosensory cortex, where layer 4 neurons are clustered into barrels, each responding primarily to input from one principal whisker (PW). The spatial arrangement of the barrels reflects the spatial arrangement of the whiskers on the animal's snout, thus representing the whiskers in a somatotopic map. Within a barrel, neurons are selective for the direction in which the PW is deflected, and across layer 2/3 directions may be organized into a pinwheel map such that deflection of whisker A towards whisker B activates barrel field A neurons located closest to barrel field B [1] (Figure 1c). More recently layer 5 neurons have been found to be selective for the direction in which waves of sequential deflections are applied across multiple whiskers, although the potential spatial organization of a map for these stimuli has not yet been determined [2].

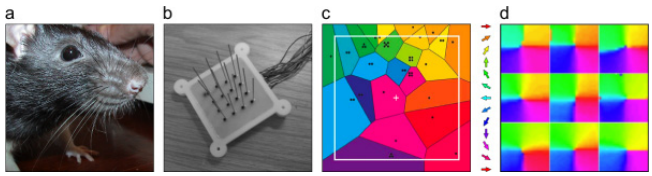

Figure 1
The development of a physical model of the rat whisker system (a). A prototype of the sensor system from which we can measure realistic whisker stimulus interactions is shown in (b). A somatotopic map for whisker direction measured across the horizontal extent of one layer 2/3 barrel field [1] is reproduced from [1] and shown in (c). (d) A layer 2/3 map that emerges in nine simulated barrel fields based on multi whisker inputs [3].

In previous work [3] we have shown how single whisker direction maps can emerge from a LISSOM (laterally interconnected synergetically self-organizing map [4]) model of layer 2/3 barrel cortex, when the directions of waves of multi whisker input are correlated with the directions of the individual whiskers. Here we investigate the emergence and organization of multi whisker representations in an additional sheet of layer 5 neurons. Self organization of this system is driven by signals measured from an array of simulated whiskers, however, work is currently in progress to generate training data from an array of physical composite glass fiber whiskers (Figure 1b) mounted on an XY translation table.

The hardware based approach allows us to investigate how cortical representations for temporal features such as stimulus onset/offset, velocity and frequency might be integrated with those for the spatial components of whisker stimuli, and should enable us to predict receptive field properties of layer 5 cells that may be measurable in future *in vivo* experiments.

References

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